Sight Distance on Horizontal Curves

Objects such as cut slopes, walls, buildings, bridge piers, and longitudinal barriers can create sight obstructions on the inside of curves (or the inside of a median lane on a divided highway). If removal of the object is not a possibility, then the alignment of the roadway may need to be altered to provide adequate sight distance.

For the purpose of designing a horizontal curve, the sight line is a chord of the curve. Sight distance is measured along the centerline of the inside lane around the curve, see Figure 1. The distance M is the minimum distance an object needs to be located from the center of the inside lane to provide adequate sight distance.
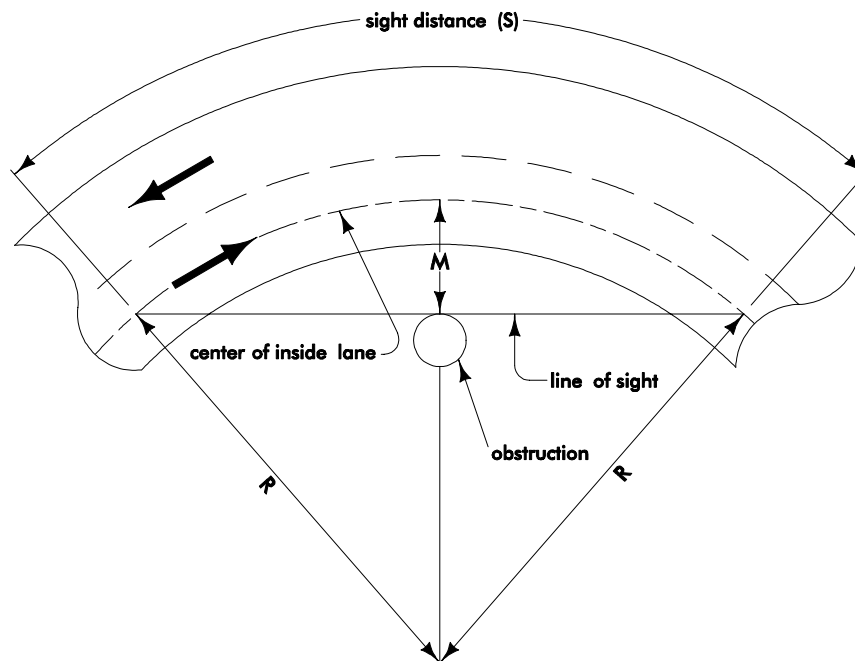
Figure 1: Sight distance along a horizontal curve.

The relationship between R and M is given as:

$$M = R\left(1 - \cos\frac{28.65S}{R}\right)$$

where R is the radius of the curve based on design speed and S is the stopping sight distance. The quantity (28.65S/R) is expressed in degrees. This equation applies when the length of the curve is greater than the stopping sight distance. Once M has been determined, other issues such as clear zone distances must also be considered when determining the distance an object needs to be from the roadway. The example on the next page provides a demonstration of how the equation is used.

In cut areas, a cut slope on the inside of a curve may obstruct sight distance. Considering the driver's eye to be at a height of 3.5 feet (1080 millimeters) and the object to be at 6 inches (150 millimeters), a height of 2.0 feet (600 millimeters) may be used as the midpoint of the sight line where the cut slope may present an obstacle (assuming little or no vertical curvature).

Since passing sight distance is much greater than stopping sight distance, clear sight areas on the inside of curves will require much greater widths than compared to widths required for stopping sight distance. Although the equation for finding M may be used for passing sight distance as well, the results are practical only for longer curves (radii of three or more times R_{min}). These results however could be used to demonstrate the need for very flat curves if passing sight distance is required, which in turn may be valuable information when choosing between design alternatives.

Example (Sound Barrier)

A horizontal curve for a four-lane section of a freeway in an urban area is to have a design speed of 60 mph. Site conditions necessitate a 1,250-foot radius curve. A 20-foot high sound barrier is required in this area. If the freeway has a 64-foot median, how far from the centerline of the freeway will the barrier need to be located to satisfy minimum stopping sight distance requirements?

The center of the inside lane is located 50 feet from the centerline of the freeway, as shown in Figure 2. This is determined by adding ½ the width of the median (32 feet) plus the width of the outside lane (12 feet) plus ½ the width of the inside lane (6 feet): 32 feet + 12 feet + 6 feet = 50 feet. Thus R = 1,250 feet – 50 feet = 1,200 feet. From Table 1 in Section 6D-1 using a design speed of 60 mph, stopping sight distance is 570 feet.
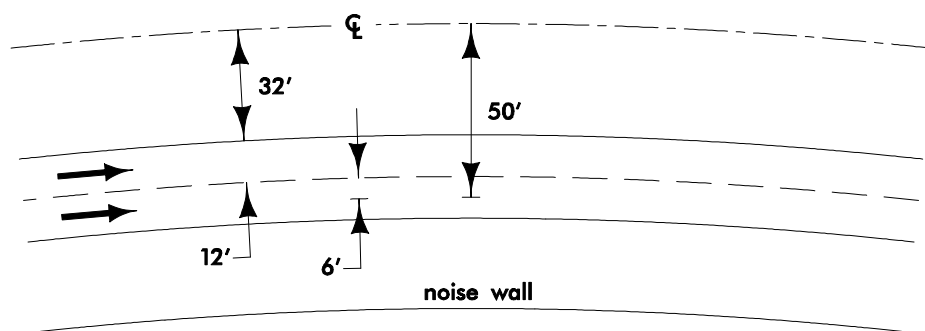
Figure 2: Determining the distance from centerline to center of inside lane.

From this,

$$M = R\left(1-\cos\frac{28.65S}{R}\right)=1200\left(1-\cos\frac{28.65\times570}{1200}\right)$$

$$= 33.7 \cong 34 \text{ feet.}$$

The distance the barrier needs to be from the freeway centerline is about 34 feet (barrier to center of inside lane) + 50 feet (center of inside lane to centerline of freeway) = 84 feet. This value represents the minimum distance needed to satisfy stopping sight distance requirements. Clear zone requirements also need to be checked. Section 1C-2 discusses clear zones in more detail. Suppose ADT will be 8850. Using information from Section 1C-2 with a design speed of 60 mph, the clear zone is 30 feet (33 feet if the curve is preceded by a tangent that exceeds one mile). Using stopping sight distance requirements places the barrier 34 feet (barrier to center of inside lane) – 6 feet (center of inside lane to edge of traveled way) = 28 feet from the edge of traveled way. This is less than what is required to meet clear zone requirements and if possible the barrier should be placed at least 30 feet from the edge of traveled way (33 feet if the curve is preceded by a tangent that exceeds one mile) or shielded with barrier.

The same procedure is used for metric units.

Example (Median Barrier)

Suppose another section of the freeway in the previous example requires a 16 foot paved median with 44-inch tall concrete median barrier rail. Assuming a 6-foot inside shoulder, what is the minimum radius required to avoid sight distance problems?

The face of the barrier rail is located about 1 foot from the centerline of the roadway (see Standard Road Plan RE-44A). The center of the inside lane is located 20 feet from the centerline, as shown in Figure 3. This is determined by adding ½ the width of the median (8 feet) plus the 6-foot shoulder plus ½ the width of the lane adjacent to the median (6 feet): 8 feet + 6 feet + 6 feet = 20 feet. The distance from the center of the lane to the face of the barrier rail is M in Figure 1. For this example, M = 20 feet (the distance to the centerline from the center of the lane) – 1 foot (the distance to the centerline from the face of the barrier rail) = 19 feet. Stopping sight distance is 570 feet.
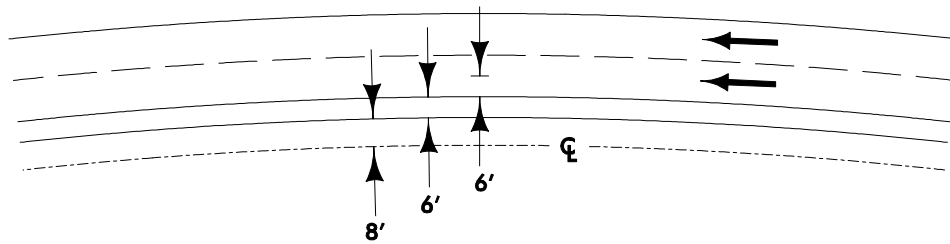
Figure 3: Determining the distance from centerline to center of lane.

From this,

$$M = 19' = R\left(1 - \cos\frac{28.65 \times 570}{R}\right)$$

This cannot be solved directly for R, so different values of R are tried until a value of M equal to or slightly less than 19 feet is achieved. Using an M slightly less than 19 feet will produce an R slightly more than the minimum required for sight distance. For R = 2,130 feet, M = 19.04 feet, which is a bit too large. For R = 2,140 feet, M = 18.95 feet, so use 2,140 feet. To find the radius to the centerline, subtract out the distance from the center of the inside lane to the centerline, which is 20 feet as shown in Figure 3. The radius to the centerline is 2,140 feet – 20 feet = 2,120 feet.

The same procedure is used for metric units.